Preliminary Result of the Occultation by (3200) Phaethon as Observed at Ballarat, California

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Near-Earth asteroid (3200) Phaethon is the primary target for the Demonstration and Experiment of Space Technology for INterplanetary voYage, Phaethon fLyby and dUst Science Phaethon fLyby with reUSable probe (DESTINY+) mission, currently being developed by the Japan Aerospace Exploration Agency (JAXA). The size of Phaethon is measured to be about 5–6 km, although numbers derived by different techniques are not in strict agreement: radar measurement suggests an sphere with a diameter of 6.2 km, or a top-shaped figure with equivalent spherical diameter of 5.5 km (Taylor et al. 2019), while two thermophysical models based on infrared data suggest a spherical diameter of 5.1 ± 0.2 km (Hanuš et al. 2016) and $4.6^{+0.2}_{-0.3}$ km (Masiero et al. 2019), $\gtrsim 2\sigma$ different from radar data.

On UT 2019 July 29, Phaethon passed in front of a 7.3 mag star SAO 40261, providing an unique opportunity to constrain Phaethon's size using a technique other than radar or thermal observation. The occultation was visible in a narrow strip from southern Colorado to central California. Guided by the prediction made by Southwest Research Institute (SwRI) based on JPL orbit solution #701,[8] we traveled to the deserted town of Ballarat, California to observe this occultation. According to the prediction, the center line would pass about 1.5 km north of the town center. We set up two telescopes, an Astro-Tech 72 mm refractor and an Astro-Tech 60 mm refractor, at 36°2'58.″9 N, 117°13'34.″3 W, ~1 km south of the predicted center line, though preliminary post-occultation analysis showed that this site is within ~100 m of the true center line (S. Preston 2019, private communication). The telescopes were about 25 m apart, with the 72 mm telescope to the south and the 60 mm telescope to the north, in a direction that was roughly perpendicular to the motion of Phaethon's shadow. For each telescope, we used a QHY CMOS camera to record the event at a frame rate of ~30 frames per second.

The "south" telescope successfully recorded the occultation; the "north" telescope did not collect any useful data due to a pointing issue. Figure 1 shows the light-curve derived from the data collected by the "south" telescope. The duration of the occultation is 0.498 ± 0.004 s. Considering the speed of Phaethon's shadow to be 11.15 km s^{-1}, corrected for Earth's rotation at Ballarat, the length of the shadow is 5.55 ± 0.05 km, in agreement with the radar

measurement. We note that this does not automatically reject the thermophysical models, as we could be measuring the long axis of Phaethon. A detailed analysis of this occultation event, using the full set of observations collected by International Occultation Timing Association members and a SwRI team, is underway.

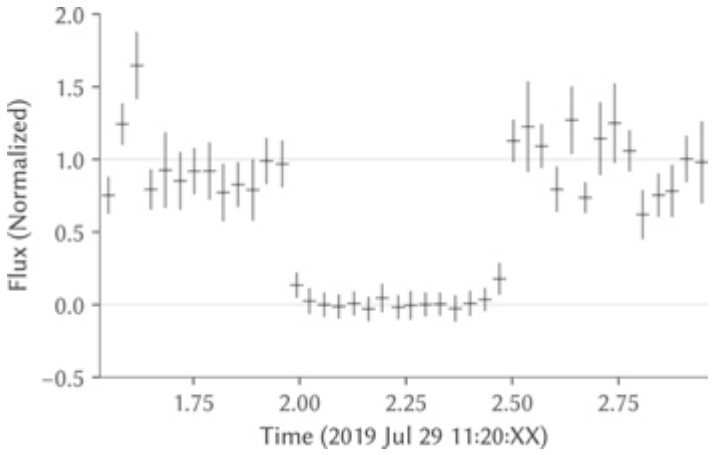

Figure 1. Light-curve of occultation as recorded by the "south" telescope. Times are in UT and have an absolute error of 0.03 s. A time-lapse video of the occultation event is available online.

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Footnotes

8 http://iota.jhuapl.edu/20190729PhaethonBefore.htm

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